TECHNICAL REPORT 01-01

EVALUATION OF FLEXIBLE PAVEMENTS IN REGION 5 CONSTRUCTED WITH GRAVEL AGGREGATES

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ABSTRACT

This study was undertaken due to concerns from Region 5 that the service lives of flexible pavements containing gravel coarse aggregate were shorter than those of flexible pavements containing crushed stone coarse aggregate. The objective was to determine if the use of gravel aggregates shortens the service life of flexible pavements and if so, what properties of the gravel cause this to happen.

Nine pavements were selected at random. One additional pavement was included, at the request of Region 5, as an example of a poor performing pavement constructed with gravel aggregate. The field investigation began with the collection of distress data and inspection of each pavement site by a team of Department personnel. The distress data was analyzed and used with team member observations to identify sites that were exhibiting prematurely high levels of distress. Sites identified as exhibiting prematurely high levels of distress were included in the subsequent evaluation phase.

A list of the pavements exhibiting prematurely high levels of distress was provided to Region 5 Materials. Region 5 provided information on pavement history and pavement condition prior to the most recent reconstruction of each pavement. Region 5 also gathered documentation from the most recent reconstruction contract file regarding paving dates, weather conditions, construction equipment and other relevant information. This information was reviewed by the Materials Bureau in an attempt to determine what factors may have contributed to distress.

Cores were located by the investigation team at each gravel aggregate pavement site. Each core was extracted and analyzed to determine the petrography of the coarse aggregate. The petrography of each core was used to confirm the aggregate source. Petrographic differences were evaluated to determine what roll each gravel source may have played in pavement performance.

Three of the pavements were in very good condition, all of which contained gravel aggregate. Four pavements were in good condition, all of which contained crushed stone aggregate. Three pavements were partially or entirely in poor condition, all of which contained gravel aggregates. The review of pavement history and construction records revealed strong evidence that most of the distress was related to construction practices. Severe distress such as transverse cracking and longitudinal joint raveling was determined to be related to problems with specifications, beyond the control of Regional Construction personnel. Subsequent revisions to Department specifications have been made to address these problems State wide. No relationship of cause and effect could be established between aggregate type and distress formation.

It is the finding of this study that gravel aggregate, and in particular southern tier gravel, has no inherent characteristic that causes a detrimental effect on pavement service life, when proper design protocol and construction practices are followed. However, evidence that pavements in Region 5 containing gravel coarse aggregate are overlaid or reconstructed at shorter intervals than pavements containing crushed stone coarse aggregate warrants further study.

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List of Photos

Acknowledgments

The following people are gratefully recognized as having contributed to this study.

Marilyn Bradley	Linden Phillips	Bill Skerritt
Chad Corbett	Ed Posluszny	Jack Sprague
Bob Longtin	Region 5 Materials Office	Charley Stone
Pete Melas	Bob Sack	Tom Wohlscheid

OBJECTIVE

This study was undertaken due to concerns from Region 5 that the service lives of flexible pavements containing gravel coarse aggregate were shorter than those of flexible pavements containing crushed stone coarse aggregate. The objective of the study was to answer the following questions:

1. Do flexible pavements that contain gravel aggregate provide similar service lives as flexible pavements containing crushed stone aggregate?
2. If any differences in service lives exist, what inherent characteristics of gravel(s), in particular southern tier gravels, are responsible for that difference?

OVERVIEW OF EVALUATION PROCESS

The evaluation process consisted of three phases of investigation: field investigation and data collection, an investigation of pavement history and construction practices of poor performing pavements and correlation of petrographic content of gravel aggregate to pavement performance. An evaluation of the friction performance of blends of gravel and carbonate crushed stone was also performed in addition to the core study. Appendix A contains a flow cart of the evaluation process.

FIELD INVESTIGATION

PAVEMENT SELECTION

Thirty-four sites were identified as candidates for the investigation. The selected pavements needed to cover a representative cross section of pavement types, aggregate types, HMA producers and contractors, with a narrow range of ages. A search of the bid analysis management system (BAMS) was performed to find HMA Items constructed in Erie, Chatauqua, Cattaraugus, and Stueben Counties for the years 1991 to 1994. To minimize the role of underlying pavement condition in treatment performance, single coarse overlays were not considered for the study.

Nine of the thirty-four candidate pavements were selected for the study. All nine pavements were randomly selected from the list of projects constructed in 1993 or 1994. The years 1993 and 1994 were chosen, because they allowed the inclusion of projects with in-place density specifications (HD and A RA). HD and RA projects required HMA mixtures and compaction techniques similar to the mixtures and construction practices used on current projects.

Of these nine projects, five were overlays of full depth flexible pavements, two were flexible pavements over cracked and seated PCC, one was a flexible overlay of rigid pavement and one was a flexible pavement over rubblized PCC. The projects represented work performed by eight contractors, seven HMA plants, and six types of coarse aggregate (two stone and four gravel sources)

A tenth pavement was provided by Region 5. It was reported to be a poor performing pavement containing gravel aggregate. This project, Route 62 from Kennedy to Frewsburg, was a two course

overlay of a full depth flexible pavement with some areas of full depth construction, constructed in 1996. Appendix B provides pertinent information on each of the selected sites.

Two sites in Stueben County were also selected and evaluated. Both sites were constructed with crushed stone aggregate. Because these sites were in Region 6 and neither added significant information to the study, they were not included in this report. The information gathered on these pavements will be used for a separate investigation being performed in cooperation with Region 6.

INVESTIGATION TEAM

A team was assembled of personnel from multiple program areas. Five members were included on the investigation team: Brad Allen, Materials Bureau, Field Engineering 2, Bill Skerritt, Materials Bureau, Engineering Geology, Charley Stone, Construction Division, Region 5 Construction Liaison, Pete Melas, Transportation Maintenance Division and Jack Sprague, Region 2, Regional Materials Engineer. Each team member was selected due to their unique background and area of expertise.

PAVEMENT EVALUATION PROCEDURE

All five team members traveled to Region 5 for the investigation. The investigation was performed during three days. Distress data was collected according to the procedures of the Pavement Rehabilitation Manual, Volume 1, except only one direction was evaluated for each pavement. For consistency, one team member recorded all distress data. Distress types, quantity and severity were recorded for each pavement. Each team member took notes on each pavement's condition. The data and notes were used to determine the condition of the pavement relative to its age and traffic loading.

PAVEMENT EVALUATION FINDINGS

Each pavement was given an overall rating by the Team. The ratings of very good, good or poor to indicate that the level of distress was less than expected, as expected or more than expected, respectively, given each pavement's age and traffic loading. This rating was based both on the quantitative collection of distress data and the qualitative opinions of the Team members. The ratings presented here are the consensus agreement of all five team members.

Three pavements were in very good condition, all of which contained gravel aggregate. Four pavements were in good condition, all of which contained crushed stone aggregate. Three pavements were partially or entirely in poor condition, all of which contained gravel aggregates. Both Route 60 and Route 62 both contained distinct areas in good condition and distinct areas in poor condition. Pavement descriptions are given in Appendix C. Descriptions of pavement conditions and summary tables of distress types and severities for all ten pavements are given in Appendix C.

Significant differences exist between the relative ratings given to each pavement by the inspection team and the pavements' surface scores given in the Highway Sufficiency Manual. The team decided not to use surface scores in this evaluation, because of possible bias. Surface score evaluations are conducted from vehicles moving at the posted speed limit, handicapping pavements with lower speed limits and pavements that more clearly display distress. It was noted by several members of the Team that cracking was much easier to see on pavements containing gravel aggregate. The team attributed this to the mottled appearance that gravel aggregate pavements take on from surface pocking. By observing each pavement on foot, the inspection team was able to reduce the effect of the mottled

surface and more objectively compare pavements containing the various types of coarse aggregates. Appendix C contains a table of surface scores for all ten pavements.

PAVEMENTS RECOMMENDED FOR FURTHER EVALUATION

The three pavements rated, at least partially, in poor condition, Route 60, Route 62, and I-86, were included in the document review portion of the evaluation. These three were the only pavements with extensive areas of moderate or severe distress. The most prominent of the distresses were full width transverse cracking, longitudinal joint cracking, raveling and wheelpath cracking. In addition to areas with moderate to severe distresses, both Route 60 and Route 62 had large percentages of pavement exhibiting little or no distress.

During the pavement evaluations evidence was found to suggest that pavements containing gravel aggregate from different sources undergo different amounts of surface aggregate deterioration. The gravel aggregate pavements found further west, Route 60, Route 62 and I-86 appeared to have more surface coarse aggregate deterioration than the eastern pavements, Route 219 Salamanca, Route 219 Carollton and Route 417. The observation of surface deterioration led the investigation team to question the impact of surface coarse aggregate degradation on pavement friction. This is of particular concern when the non-carbonate aggregate content required for friction is obtained by blending gravel with carbonate crushed stone, as is commonly done in northern Region 5. A companion investigation of pavements constructed in Region 5 with blends of gravel and crushed stone coarse aggregate was undertaken to resolve this issue. The findings of this companion investigation are in Appendix F.

PAVEMENT HISTORY AND CONSTRUCTION PRACTICES REVIEW

RESEARCH PROCEDURE

Region 5 Materials Office provided the following documentation for Route 60, Route 62 and I-86.

1. Pavement Evaluation and Recommendation Reports prepared by the Regional Materials Office for use by the Regional Design office in selecting the appropriate pavement rehabilitation treatments.
2. Daily Field Inspection Reports for paving days during the most recent rehabilitation project.

Copies of relevant plans were obtained from the Main Office Design, Record Plans. These documents were reviewed along with the data gathered by the investigation team in Phase 1 in an attempt to determine the cause of early distress occurring at Route 60, Route 62 and I-86.

Findings of the document review, relevant to the visible distresses, are provided in Appendix D. The information provided in Appendices B and C was used to determine the most likely cause of the pavement distresses, presented below.

Discussion of Most Probable Causes of Pavement Distress

This section presents the most likely causes of the major pavement distresses observed during the pavement evaluation process. This discussion does represent the sole opinion of the author. The full resources of the Materials Bureau, including consultation with experts in flexible pavement construction and rigid pavement rehabilitation, were used to develop the information presented below.

Regularly spaced Full Width Transverse Cracking

Figure 1 - Regularly Spaced Full Width Transverse Cracking on Route 60

Regularly spaced full width transverse cracking was observed on the entire length of the I-86 project and at Route 60 from RM 60 5201 3095 to 3158. Each of these pavements had extensive areas with moderate to severe full width transverse cracks spaced at 20, 30 and 60 foot intervals. During the document review process these pavements were found to have similar pavement sections and rehabilitation histories.

Both Route 60 and I-86 had previously been rigid pavements. Each had been cracked and seated and overlaid with HMA; Route 60 in 1984 and I-86 in 1993. The appearance of full width transverse cracking at regular intervals suggests that most of the cracking is reflective of joints and midslab cracks in the underlying PCC pavement. The Region's 1991 pavement evaluation report for Route 60 notes that most of the transverse cracking present at that time (approximately the same quantity and severity of cracking present today) was reflecting from the original joints in the underlying PCC pavement.

The appearance of reflective cracking on these pavements suggests that crack and seat operation was not effective, and the original pavements are still acting as twenty to sixty foot rigid slabs. This situation is usually the result of either poor treatment selection, or construction practices. The PCC pavement would have been a poor crack and seat candidate, if there was not a significant amount of mid-slab cracking. Construction practices would be to blame if the pavement were not impacted with enough force to fully crack the slab.

For Route 60 there was insufficient evidence in the historical documents to pinpoint the cause of failure, but based to the age of the pavement multiple midslab cracks should have been present in 1984. According to the Region's pavement evaluation 1991 report, I-86 had significant slab cracking at ½ and ⅓ points. This suggests that the pavement was an appropriate candidate for crack and seat. The most likely cause of the full width transverse cracking on both pavements is insufficient impact during the cracking operation. Insufficient impact energies were common on crack and seat projects prior to the Department's purchase of a Falling Weight Deflectometer (FWD) in 1994. The FWD is now used on all crack and seat projects to establish the proper drop height of the cracking guillotine.

Full Width Cracking Over Culverts

The most prominent distress on Route 60 from RM 60 5201 3040 to 3095 was full width cracking located above or near culverts, most likely caused by improper compaction of granular subbase or loss of material from around the culverts. No evidence of general pavement failure exists in this area that would suggest any problems with the HMA mixture or its coarse aggregate. The pavement in this area was mostly in good condition.

Centerline Joint Cracking, Raveling, and Map Cracking

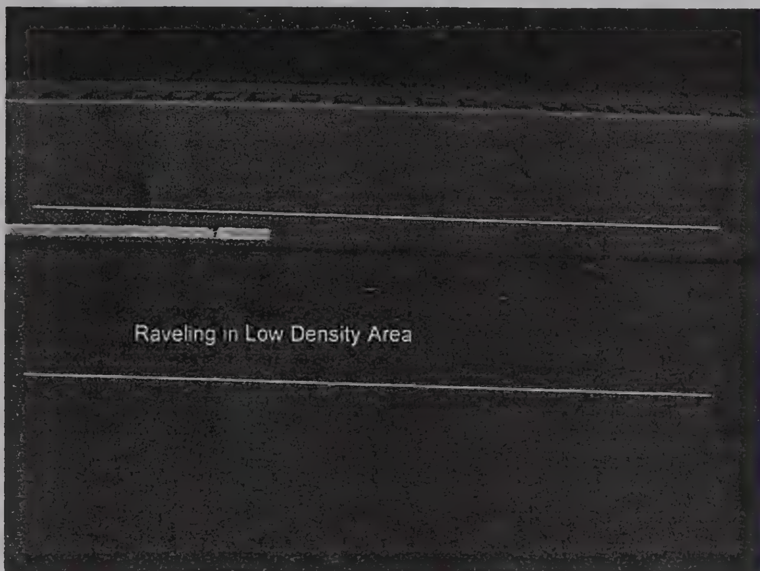


Figure 2 - Distress Concentrated in Driving Lane on I-86

These three distresses are discussed here together, because it is the conclusion of this investigation that each are resultants of the same cause.

Almost the entire length of I-86 displayed moderate to severe longitudinal cracking along the centerline joint and low severity map cracking in the driving lane adjacent to the centerline joint. Approximately 50% of Route 62, from Kennedy to CR 318 displayed low to moderate severity longitudinal cracking at the centerline joint.

Cracking at and near the longitudinal joint is usually indicative of poor construction practices. Cracking solely at paving joints is not considered an indication of aggregate breakdown. Raveling can be caused by poor pavement density or aggregate degradation. Raveling caused by degradation would be evidenced by the presence of broken aggregate particles in the raveled areas. This was not seen during the field evaluation.

Most of the raveling at the centerline joint and map cracking surrounding the joint on I-86 was in the driving lane. According to the construction records, the paving operation was phased to pave the passing lane before the driving lane. When longitudinal joints are not constructed properly, it is common to see most of the distress in the lane paved second, the hot side of the joint.

At the time these projects were constructed the specified joint compaction method was to make the initial compaction pass with most of the drum on the previously placed mat, the cold side of the joint, and only six to twelve inches of the roller on the hot side. The roller would then move to the outside of the hot mat for the next pass, and move closer to the longitudinal joint with each subsequent pass. On the final pass some portion of the roller would most likely be on the cold mat.

During the initial pass the roller could only compact the hot side of the joint to the height of the cold side. If the hot mat was not placed thick enough by the paver, the material at the joint would not be sufficiently compacted. If on the final pass any portion of the roller was on the cold side of the joint, the load exerted by roller would be concentrated at the ends of the drum. This would reduce the

Figure 3 - Severe Raveling of Centerline Joint on I-86

roller's ability to compact the material in the center of the drum, the material within one to four feet of the joint. This is commonly called "bridging" the joint.

The reconstruction of this section of I-86 was the first project in Region 5 constructed according to the Heavy Duty HMA (HD) specification. Route 60 was constructed according to the Rut Avoidance (RA) specification. The HD and RA specifications introduced new mixture design and compaction monitoring requirements. While these specifications were developed to improve pavement density, on some early contracts, the specification may have contributed to poor longitudinal joint density. According to the HD and RA specifications used for these projects, pavement density was monitored by cores and nuclear gauge readings respectively, which were taken at random locations, but could not be taken within 2 feet of a longitudinal joint. Based on the density testing, the Contractor could receive payment greater or less than the bid price. This system, gave incentive to the Contractor to expended more effort in compacting the center of each paving pass than along the longitudinal joint. Since the completion of this project, the Department has taken several steps to improve longitudinal joint density. The roller pattern for compacting longitudinal joints was modified, to place only six to twelve inches of the roller on the cold side of the joint during the initial pass. Also, separate longitudinal joint density specifications were piloted, giving contractors incentives to properly compact longitudinal joints.

Wheelpath Cracking

Route 62, north of CR 318, exhibited extensive cracking in the right wheelpath of each lane. This condition was only found from Kennedy to CR 318, the same areas in which the longitudinal joint cracking was present. No wheelpath cracking was present from CR 318 to the Village of Frewsburg.

Wheelpath cracking is usually an indication that a pavement has reached the end of its service life and no longer has the structural capacity to handle the traffic load. If this were the case, cracking would be expected to be present in all wheel paths. On Route 62, cracking was only found in the right wheel path of each lane. The surface texture in the cracked area was also much rougher than the surrounding pavement. Upon close examination it was discovered that the right wheel paths were located at the approximate center of the paving passes. Open pavement texture and cracking along the center of a paving pass are indications of a construction related problem called center-screed segregation.


Figure 4 - Distress Aligns with Center of Paver on Route 62

Center-screed segregation is caused by a concentration of coarse aggregate in the center of the auger area directly in front of the paving screed. The augers are driven by a transfer case at the center of the screed. The location of the transfer case reduces the paver's ability to keep a homogeneous mixture at the center of the screed. If proper paving practices are not followed, this can lead to segregation below the transfer case. Some HMA mixtures are more susceptible to segregation, and some pavers are more likely to cause center-screed segregation, but center-screed segregation can be avoided with proper paving practice.

PETROGRAPHIC ANALYSIS OF GRAVEL AGGREGATE

General Discussion of Gravels Found in Region 5

Gravel

Gravel is granular material usually composed of a variety of rock types. New York State gravels are almost entirely of glacial origin deposited during the Pleistocene Epoch of geologic history. Southern tier gravels were derived from bedrock formations to the north that occur in east-west trending outcrops. Consequently, southern tier gravels contain similar suites of rock types, but in differing proportions. Unprocessed gravel quality is controlled by the quality of the component rocks and the degree to which they have been "worked" by the glacier and by the subsequent deposition. Generally, gravel quality is improved by the crushing, abrading, and washing actions they experience during water transport away from the glacial ice.

Geologists can learn about relative gravel quality through the interpretation of land forms and their internal structure. Outwash and ice-contact deposits, occurring in land forms such as deltas and kames, are produced by more vigorous water transport and are generally of higher quality, than stratified drift, occurring in moraines, that has received little or no water transport.

Gravel Characteristics

The composition of gravel in the southern tier can include rocks of widely differing engineering characteristics, which, in addition, usually vary with particle size in their relative proportions. The largest particles are usually more locally derived and often of lesser quality. By contrast, crushed stone is generally of the same basic rock type with some variations occurring from layer to layer. Gravel, by virtue of its particle size-dependant compositional variation, can display quality differences arising from

raw feed gradation differences. Crushed stone, on the other hand, is generally very uniform, so long as it is consistently mined from the same layers.

Variations in Gravel Quality

When gravel is subjected to the standard battery of aggregate tests, the results are in effect a "weighted average" of the different components' individual test results. If the individual components have similar responses to physical tests, the composite test result accurately reflects the nature of its components. However, if the individual components have widely differing responses to the physical tests, the composite test result may be misleading. When very high quality gravel components coexist with lower quality components, the high quality materials mask the behavior of the low quality materials in the physical tests, including the magnesium sulfate soundness test and the freeze-thaw test. In extreme cases, the low quality gravel components are designated as deleterious materials and are restricted by specification (see Table 703-3 in the Standard Specifications). Many non-durable rocks deteriorate completely, if exposed to weathering for sufficient time. If sufficiently low quality gravel components constitute a large enough proportion of the total coarse aggregate, less than desirable performance could result. The inability of the standard battery of physical tests to adequately differentiate gravels having components of differing qualities suggests that actual performance may be less predictable with gravel than with crushed stone. However, this fact is not sufficient reason to either dispense with the tests or to exclude gravels.

Relationship between Surface Distress to Durability

Three types of pavement distress can be caused by non-durable aggregate particles: pocking, raveling and potholes. Other distresses, notably cracking, are not generally related to aggregate durability. Pocking is the complete or partial loss of aggregate particles by degradation, leaving behind a socket. If severe enough, pocking may result in raveling, wherein portions of pavement mat are lost. Further progression may result in potholes.

Pocking is generally associated with gravel pavements but often occurs on crushed stone pavements as well. All six of the pavements containing gravel included in this study exhibited pocking to some extent, as did Route 39, which contained crushed stone. Pocking is easily recognizable on gravel aggregate pavements, because gravel is a natural blend of several different types of stone. When these stones are exposed by pavement wear they appear as small spots of different colors, producing a mottled appearance. When pocking occurs on crushed stone pavements it is often difficult to observe, especially from a moving vehicle, because the crushed stone is uniform and often grey in color. Figures 5 and 6 demonstrate the difference in appearance between pocked pavements containing gravel and crushed stone aggregate. The amount of surface aggregate loss is similar, but it is much more noticeable in the pavement containing gravel.

Figure 5 - Pocking on Route 62

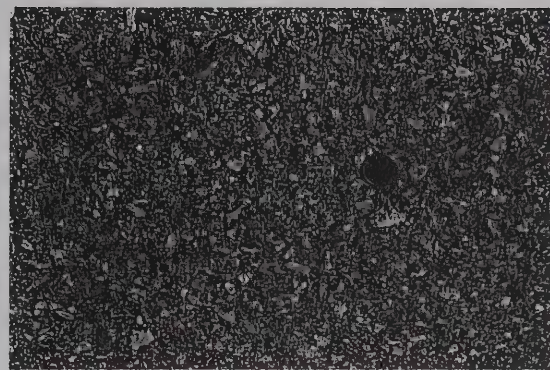


Figure 6 - Pocking on Route 39

There were no pavements in this study where pocking was found to be the cause of further pavement distress. Pocking alone is not necessarily a cause for concern. Pocking normally occurs during the first winter season after a pavement is constructed. Following this initial loss of material, pocking rarely progresses.

Evaluation of Pavement Samples

One pavement sample was taken from each gravel pavement site. The asphalt binder was extracted from each sample by the ignition method, and the recovered aggregate was identified by the Materials Bureau's Engineering Geology Section. Petrographic data from the project cores were compared with Petrographic data from biennial test samples of the coarse aggregate of record from the project. In all cases, there was no indication that coarse aggregate was supplied from an alternative source. Appendix E contains a summary of petrographic compositions and a comparison of historical test data related to aggregate durability for each gravel source in this study.

Relating Petrography to Pavement Performance

Field observations of this Gravel Study show that the pavements associated with the greatest distress contained gravel from Source G, and were produced by the same HMA producer. Gravel from Source G cannot serve as the representative of other southern tier gravels. As seen in the data Appendix E, G gravel comes from an end moraine and the other two gravels come from outwash deposits. This means that, even if all three gravels contained materials derived from the same bedrock sources, the differing degrees to which they have been "worked" would render them of different qualities. Because of this difference in geologic origin, there is no means of knowing whether changing only the gravel source would alter the pavements' performances. Therefore, the cause of these distresses cannot be assigned solely to the aggregate.

No universal correlation could be established between aggregate petrography and pavement performance. The aggregate sources in this study all had similar materials in similar proportions. These similar materials were used in pavements with a wide variation of performance. This study did not find a specific component or combination of components that directly related to pavement performance.

CONCLUSIONS

Preconstruction pavement condition, treatment selection, construction practices, HMA mixture design, aggregate quality, pavement management practices and quality of construction materials all play significant rolls in service life. The review of pavement histories and construction records of the projects exhibiting premature distress uncovered evidence supporting the field observations that the distress was related to construction practices. Many of the poor construction practices were the result of inadequate specifications. The failed cracking and seating of both Route 60 and I-86 and the poor longitudinal joint performance on I-86, were directly related to inadequate specifications and poor quality assurance test methods. Since the early 1990s the Department has expended considerable energy in improving its paving specifications. Crack and seat projects have experienced good success since introduction of the FWD, and longitudinal joint density has been improved through various techniques including the pilot use of incentive and disincentive payments. These and many other technological advances over the past several years are expected to improve the durability of all new pavements.

Although some of the gravel aggregate pavements have not performed to the level that should be expected, this study revealed no evidence that the existing distresses are the direct result of poor quality aggregate. The findings of this study indicate that many factors other than aggregate performance have contributed to the high levels of distress on some of the evaluated pavements. This study has not shown a positive correlation between the use of gravel aggregates and inferior pavement performance.

RECOMMENDATIONS FOR FUTURE WORK

There are several outstanding issues related to the use of gravel aggregate in Region 5 that were either previously known, but not directly addressed in this study or that were uncovered by this study. The following is a list of related topics that may warrant further work or investigation.

Time to Rehabilitation

While this study did not identify a link between gravel aggregate and the development of pavement distress, there is evidence that pavements in Region 5 containing gravel aggregate are overlaid or reconstructed at shorter intervals than pavements containing crushed stone aggregate. More work is needed to determine why this occurs and to what extent.

Specifying Mixture Size

Region 5 has traditionally used, and wishes to continue using, 9.5 mm and 12.5 mm maximum aggregate size mixtures for top course paving containing gravel and crushed stone coarse aggregate respectively. It is difficult to specify the mixture size during design, when the aggregate type that will be used by the Contractor is not known until after the contract is awarded. This situation could be resolved with a pavement specification that allows for the use of either 9.5 mm or 12.5 mm mixtures depending on the type of coarse aggregate chosen by the Contractor. If the mixture to be supplied will contain gravel, the Contractor would bid on the 9.5 mm pay item. If the mixture will contain stone, the

Contractor would bid on the 12.5 mm pay item. Two cross sections would be shown on the plans to accommodate either option.

Effects of Pocking on Noise Level, Ride Quality and Aesthetics

The effects of pocking on ride quality and noise levels are unknown. At least a preliminary investigation related to smoothness, texture and noise may be warranted. Aesthetics are often a major concern for projects in urban or village environments. More work is needed to determine the relationship between pocking and perceived pavement quality.

Modified Asphalts

One means of mitigating all concerns related to pocking, is to reduce or eliminate surface aggregate loss. Pilot projects have indicated that the use of latex polymer in the asphalt binder, may reduce the amount of surface aggregate loss. More work should be done with latex modified asphalts to determine the extent to which their use may reduce pocking.

APPENDIX A

Flowchart of Evaluation Procedure

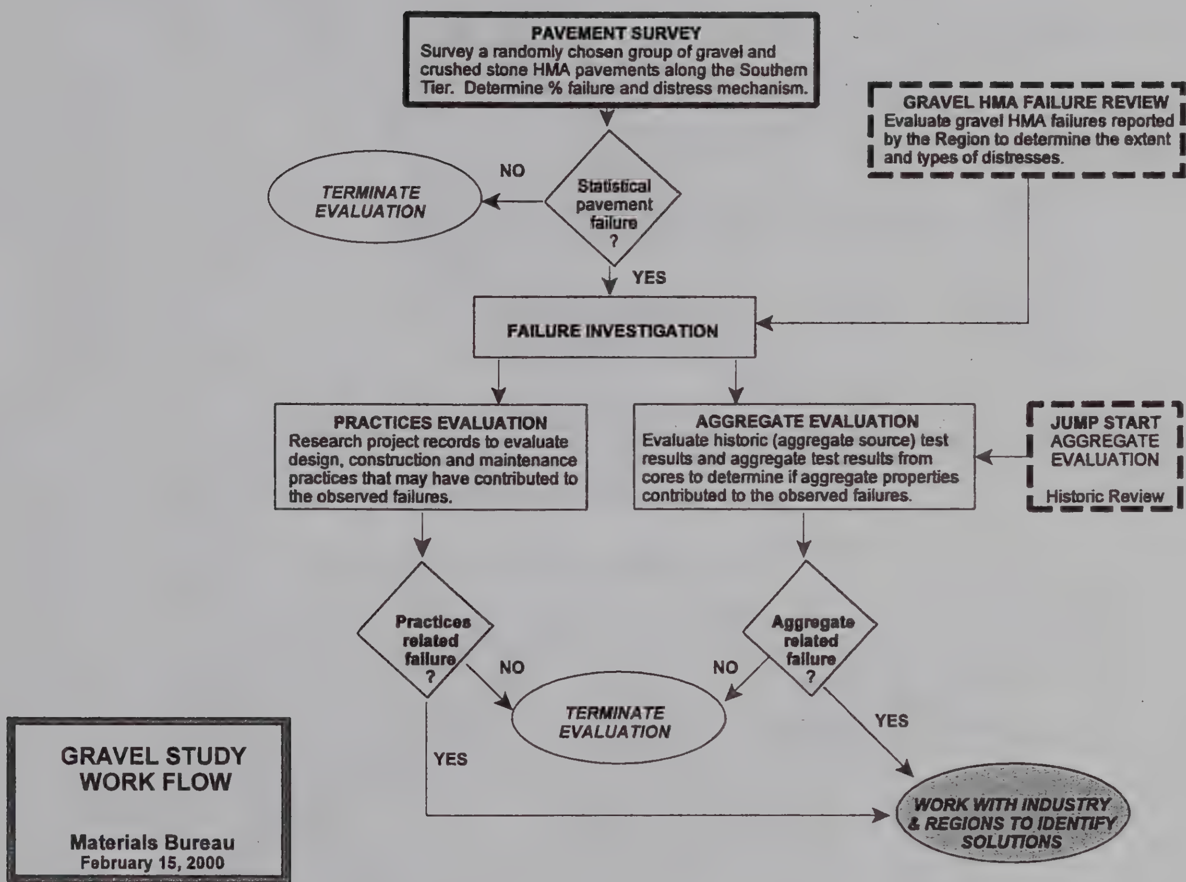


Figure 6 - Flow Chart of the Evaluation Procedure

APPENDIX B

General Pavement Information

Figure 8 - Locations of Pavement Sites 1 - 3

Figure 9 - locations of Pavement Sites 4 - 10

PAVEMENT SITES FOR INVESTIGATION

#	Contract	Year	Route & Location	Start RM	End RM	Work Description	Vendor	Producer	Producer Location
1	D256190	1994	Rte 5 Main St. Williamsville	5-5302-4025	5-5302-4038	2 course overlay of PCC	Hartford Paving Corp.	Lancaster	Clarence
2	D254725	1993	Sheridan Drive, Amherst	324-5302-1174	324-5302-1194	2 course overlay	Frontier Asphalt	Buffalo Crushed Stone	Williamsville
3	D254536	1993	Rte 20, Orchard Park	20-5302-1223	20-5302-1244	2 course overlay and full depth	Holmes & Murphey	Buffalo Crushed Stone	Cheektawaga
4	D254923	1994	Rte 39 Springville-Sardinia	39-5303-1181	39-5303-1273	2 course overlay	Joeseph J. Kelly, Inc.	County Line Stone	Akron
5	D254798	1993	Rte 60, Town of Gerry	60-5201-3041	60-5201-3158	2 course overlay	Accadia Enterprises	Jamestown Macadam	Jamestown
6	D256867	1996	Rte 62 Frewsburg	62-5201-1125	62-5201-1151	2 course overlay and full depth	Rifenburg Construction	Jamestown Macadam	Jamestown
7	D254572	1993	I-86, exit 17 to exit 20	17-5112-1100	17-5112-1199	2 course overlay of crack and seat	Depew Development	Jamestown Macadam	Jamestown
8	D256210	1994	Rte 219 Salamanca	219-5101-3045	219-5101-3088	2 course overlay	Omer Construction	Gernatt	Collins
9	D256222	1994	Rte 219 Carrollton	219-5101-1000	219-5101-1060	2 course overlay of rubblized PCC	L.C. Whitford	L.C. Whitford	Cuba
10	D254840	1993	Rte 417 Allegany	17-5102-3143	17-5102-3152	2 coarse overlay w/ full depth widening	Hartford Paving Corp.	Buffalo Crushed Stone	Olean

APPENDIX C

Pavement Conditions

Route 5, Main Street, Williamsville
RM 5-5302-4025 to RM 5-5203-4038

This section of Route 5 is a four lane urban arterial with signalized intersections. The traffic volume is approximately 30,000 AADT with 6% trucks. The pavement is a two coarse overlay of a PCC pavement constructed in 1994. The surface course is Type 6F RA with cherty limestone coarse aggregate produced by Lancaster Stone in Clarence (Source B).

The overall condition of the pavement was good. Distress consisted of reflective cracking at transverse joints and midslab cracks in the underlying PCC pavement and cracks at utility repairs. Secondary cracking has begun to form at most of the cracks. Low severity wheelpath rutting has occurred with medium severity rutting at signalized intersections.

There was no sign of coarse aggregate deterioration.

Route 324, Sheridan Drive, Amherst
RM 324-5302-1174 to RM 324-5302-1194

This section of Route 324 is a four lane urban arterial with signalized intersections. The traffic volume is approximately 20,000 AADT with 6% trucks. The pavement is a two course overlay and widening of full depth asphalt constructed in 1993 by Frontier Asphalt. The surface course is Type 6FRA with cherty limestone coarse aggregate produced by Buffalo Crushed Stone in Williamsville (Source C). The eastern end of the project was reconstructed as part of the ongoing construction of the interchange for Sheridan Drive and Transit Road. The western end of the project received a maintenance overlay of paver-placed surface treatment in 1998.

Overall condition of the pavement was good. Distress was mostly limited to intersections. Some low severity wheelpath cracking rutting has occurred. The surface has localized areas exhibiting loss of fine material. There was evidence of segregation from the paving operation, center screed segregation, and resultant cracking in the segregated areas.

There was no sign of coarse aggregate deterioration.

Route 20, from Smokes Creek to Lake Ave and Orchard Park Rd, Orchard Park RM 20-5302-1223 to RM 20-5302-1244

This section of Route 20 is a four to five lane urban arterial with signalized intersections. The traffic volume is approximately 20,000 AADT with 6% trucks. The pavement is a two course overlay of full depth asphalt with areas of full depth reconstruction constructed in 1993 by Holmes and Murphey Construction. The surface course is Type 6FRA with cherty limestone coarse aggregate produced by Buffalo Crushed Stone in Cheektawaga and Williamsville (source A). Both Cheektawaga and

Williamsville are cherty limestone sources. Why a dolomite aggregate was used at plants in these locations is unknown.

Overall condition of the pavement was good. Low severity cracking was visible at the centerline joint, the shoulder joint and in the wheel paths. Medium severity rutting and corrugations are present at signalized intersections.

There was no sign of coarse aggregate deterioration.

Route 39, Springville and Sardinia
RM 39-5303-7781 to RM 39-5303-1273

This section of Route 39 is a two lane secondary roadway with few intersections. The traffic volume is approximately 10,000 AADT with 9% to 12% trucks. The pavement is a two course overlay of full depth asphalt constructed in 1994 by Joseph J. Kelly Blacktop. The surface course is type 7F HF with cherty limestone and argillaceous dolomite corse aggregate, produced by County Line Stone in Akron. The Akron plant blends low residue limestone from Source D, with cherty limestone from other sources.

The overall condition of the pavement is good. Low severity cracking is visible at the centerline joint. A large portion of the job exhibits low severity wheelpath rutting. Most of the surface exhibits loss of some fine material, giving the surface an open appearance. Areas up to 0.1 mile long have been patched with HMA produced with gravel aggregate. Other than partial loss of surface aggregate these patches showed the same level and type of distress as the surrounding pavement.

Scattered coarse aggregate particles of argillaceous dolomite have disintegrated and appear as pock marks in the surface.

Route 60, Towns of Gerry, Charolette, & Stockton
RM 60-5201-3041 to RM 60-5201-3158

This section of Route 60 is a two lane rural secondary road with few intersections. The traffic volume is approximately 6500 AADT with 12% to 15% trucks. Part of this pavement consists of asphalt concrete of varying depths over cracked and seated PCC pavement, and part consists of full depth asphalt of varying depth. The last department project on this pavement consisted of removing the asphalt concrete to a depth of five inches and replacement with hot mix asphalt, constructed in 1993 by Accadia Enterprises. The surface course is Type 7F HF with gravel coarse aggregate, produced by Jamestown Macadam in Jamestown. This pavement will be cored to determine the source of the gravel.

North of RM 60-5201-3087, medium severity cracking is visible along the centerline joint and transversely at spacing of 20 to 60 feet. Most transverse cracking occurs at a spacing of approximately 60 feet giving the appearance of reflective cracks from the underlying concrete pavement. This area has extensive medium severity wheelpath cracking. Pavement condition improves to the south. No crack sealing has been performed on this pavement.

At RM 60-5201-3087 (after bridge) the pavement appears to be full depth asphalt with very little distress. In this southern section wheelpath cracking is reduced, longitudinal joint distress is low

severity and isolated, and only isolated transverse cracking is present. Most transverse cracking appeared over or in the vicinity of culverts.

There is a general degradation of the sandstone component of the gravel and total disintegration of some to many particles resulting in pocks. The partially degraded particles have a cupped appearance and recede beneath the pavement surface. The pocking and sandstone disintegration appear to be a surface phenomena.

Route 62, Frewsburg to Kennedy
RM 62-5201-1131 to RM 62-5201-1051

This section of Route 62 is a rural two lane secondary road with few intersections. The traffic volume is approximately 2000 AADT in the northern 5 miles and 4000 AADT in the southern three miles with 12% trucks. The pavement is a two coarse overlay of full depth asphalt pavement constructed by Rifenburg Construction. The surface course is Type 7F with gravel aggregate, produced by Jamestown Macadam in Jamestown. The northern most half mile and the portion of the project within the village of Frewsburg were overlaid with micro-surfacing by Suit-Kote Corp. in 1997. The micro-surfacing contains dolomite aggregate.

From I-86 to the intersection with CR 318 the pavement has medium severity cracking at the centerline joint and low to medium interconnected cracks in the right wheelpath. Isolated sections of the centerline joint exhibited loss of material. The right wheelpath also has a generally open appearance and in some areas both wheel paths show signs of wear. There are isolated areas of rutting on hills and few transverse cracks in the northern area. It appears that the lane and shoulder were paved at the same time. The right wheelpath is located at the approximate center of the paving pass. This evidence would suggest that the wheelpath's open appearance and cracking are due to segregation of the HMA at the center of the paving screed. Other than surface texture and color, the micro-surfacing at the northern end of the project exhibits the same types and levels of distresses as the rest of the northern section.

The southern most three miles of the project, from the intersection with CR 318 to the Village line, is in overall good condition. The wheelpath and transverse cracking is mostly single isolated cracks. The longitudinal cracking at the centerline does not show any secondary cracking. Center-screed segregation is not apparent in this area. The micro-surfaced area through the village is in good shape, similar the to areas south of CR 318 that were not micro-surfaced.

There is pocking and some degradation of the sandstone component of the coarse aggregate, similar to Route 60.

I-86 (Rte. 17) Southern Tier Expressway, Exit 17 to Exit 20
RM 17-5112-1100 to RM 17-5112-1199

This pavement is a four lane controlled access rural freeway. Traffic volumes range from approximately 7100 to 9300 AADT with between 12% to 26% trucks. The pavement structure consists PCC pavement that has been crack and seated and overlaid with 125 mm of hot mix asphalt. The surface course is Type 7F HD with gravel aggregate.

Overall, this pavement is in poor condition, exhibiting medium to high severity cracking at the centerline joint with potholes, medium severity full width transverse cracks at 20 to 60 foot intervals, and medium severity longitudinal cracking along the majority of the shoulder joint. Some wheelpath cracking is present, however, the majority of cracking, other than longitudinal of full width transverse, is map cracking that starts at the centerline joint and extends 1 to 3 feet into the driving lane. It would appear that the passing lane and inside shoulder were paved first in a single pass and the driving lane and outside shoulder were paved in a single subsequent pass. The poor joint performance indicates that the uncompacted mat for the driving lane was not placed thick enough by the paving screed, and the bridged the hot side of the joint, unable to compact the material in the driving lane for a width of several feet. No crack sealing had been performed on this pavement, but potholes at the centerline joint have been filled. Isolated areas of raveling are also present in the "low density" areas of the driving lane adjacent to the centerline joint. The entire "low density" area has an open appearance.

The aggregate appears to be similar in composition and surface appearance to the aggregate at Routes 60 and 62.

Route 219, Salamanca to Ellicotville
RM 219-5101-3045 to RM219-5101-3088

This section of Route 219 is a two lane arterial with several nonsignalized intersections. The traffic volume is approximately 6400 AADT with 12% trucks. The pavement is a two course overlay of full depth asphalt constructed by Omer Construction in 1994. The surface course is Type 7F with gravel coarse aggregate produced by Gernatt in Collins. The pavement will be cored to determine the source of the gravel.

Overall this pavement is in very good condition. Distress is limited to low to moderate severity transverse cracks, minor wheel path cracking, an low severity longitudinal cracking at the centerline joint. The transverse cracks are mostly single low severity cracks, that appear to be the result of low temperature strain. Most of the centerline joint has no cracking, and most of the cracking that is present is low severity. The wheelpath cracking is entirely low severity isolated single cracks. No crack sealing has been performed on this project.

The pavement surface shows little sign of coarse aggregate deterioration. Some pocks are present but they are isolated and not representative of the overall pavement surface condition.

Route 219 Town of Carollton
RM 219-5101-1000 to RM 219-5101-1060

This section of Route 219 is a four lane divided rural arterial with both at grade intersections and limited entrance and exit access. The traffic volume is approximately 3000 AADT with 17% trucks. This pavement is a two coarse HMA overlay of a rubblized PCC pavement constructed in 1994 by L.C. Whitford Construction. The top course is Type 7F RA with gravel aggregate produced by L.C. Whitford in Cuba. The pavement will be cored to confirm the source of the gravel.

The overall condition of this pavement is very good, except for some cracking at the centerline joint and at the joints between the mainline and entrance/exit ramps. Distress was limited to low to medium severity cracking at the longitudinal joints and isolated low severity wheelpath cracking. All of the wheel path cracks were isolated single cracks. No crack sealing has been performed on this project.

The coarse aggregate shows occasional pocks where particles have disintegrated. The majority of the visible coarse aggregate particles appear sound. Overall surface appearance is similar to Route 219 from Salamanca to Ellicotville.

Route 417, Town of Allegany
RM 17-5102-3143 to RM 17-5102-3152

This section of Route 417 is a three lane urban arterial with signalized intersections. The traffic volume is approximately 9500 AADT with 4% trucks. The pavement is full depth asphalt constructed in 1993 by Hartford Paving Corp. as a widening to provide a turning lane. The surface course HMA is Type 7F with gravel coarse aggregate produced by Buffalo Crushed Stone in Olean. The pavement will be cored to determine the source of the gravel.

The overall condition of this pavement is good to very good. Most distress is located at the intersection in front of a shopping plaza at the southern end of the job. In this area, full width transverse cracking was present. In the rest of the pavement, distress is limited to isolated transverse cracking (one crack was present in the section evaluated) and low severity wheelpath rutting.

Pavement surface appearance and coarse aggregate performance is similar to the two Route 219 sites.

PAVEMENT DISTRESS SUMMARY
CRUSHED STONE AGGREGATE PAVEMENTS

#	Location	AADT	Trucks	Condition	Distress	Severity
1	Route 5	30,000	6 %	Good	reflective cracking	low to medium
					wheelpath rutting	low - extensive medium - at intersections
2	Route 324	20,000	6 %	Good	wheelpath rutting	low - at intersections
					wheelpath cracking	low
					loss of fines	low - isolated areas
3	Route 20	20,000	6 %	Good	C.L. joint cracking	low
					wheelpath cracking	low
					wheelpath rutting	medium - at intersections
4	Route 39	10,000	9 %	Good	C.L. joint cracking	low
					wheelpath rutting	low - extensive
					loss of fines	low - extensive
					full width patches	up to 1/10 mi. long
					C.A. degradation	scattered - argillaceous dolomite

PAVEMENT DISTRESS SUMMARY GRAVEL AGGREGATE PAVEMENTS						
#	Location	AADT	Trucks	Condition	Distress	Severity
5a	Route 60 North of RM 3087	6,500	12 - 15%	Poor	reflective cracking	medium - many midslab cracks
					wheelpath cracking	medium
					C.A. degradation	general degradation of sandstone
5b	Route 60 South of RM 3087	6,500	12 - 15%	Good	long. joint cracking	low
					wheelpath cracking	low - mostly single cracks
					C.A. degradation	general degradation of sandstone
6a	Route 62 North of CR 318	2,000	12 %	Poor	C.L. joint cracking	medium
					wheelpath cracking	low to med. - rt wheelpath only
					wheelpath rutting	low - up hills only
					segregated/open	right wheelpath - center screed
					C.A. degradation	general degradation of sandstone
6b	Route 62 South of CR 318	4,300	12 %	Good	C.L. joint cracking	low
					wheelpath cracking	low - isolated
					C.A. degradation	general degradation of sandstone
7	I-86 (Rte. 17)	8,000	12 - 26%	Poor	C.L. joint cracking	medium to high w/ potholes
					reflective cracking	medium to high
					map cracking	med. - radiating from C.L. joint
					C.A. degradation	general degradation of sandstone
8	Route 219 Salamanca	6,400	12%	Very Good	transverse cracks	low to medium - few
					wheelpath cracking	low - isolated
					C.L. joint cracking	low
					C.A. degradation	minor loss of sandstone particles
9	Route 219 Carollton	3,000	17%	Very Good	C.L. joint cracking	low
					Shldr joint cracking	low to medium
					wheelpath cracking	low - few and isolated
					C.A. degradation	minor loss of sandstone particles
10	Route 417	9,500	4%	Very Good	Transverse cracking	low
					wheelpath rutting	low
					C.A. degradation	minor loss of sandstone particles

PAVEMENT SURFACE SCORES FOR GRAVEL AND STONE SITES									
Start	End	R.M.	AADT	1995	1996	1997	1998	1999	2000
5 5302 4025	5 5302 4038	5 5302 4025	33000	7	7	7	7	7	7
		5 5302 4026	15600	6	9	7	7	7	7
		5 5302 4031	24600	U	9	8	8	7	7
		5 5302 4038	34100	U	9	9	8	8	8
324 5302 1174	324 5302 1194	324 5302 1174	20600	U	9	9	9	8	8
		324 5302 1181	20600	U	9	9	9	8	8
		324 5302 1193	19200	U	9	9	9	8	8
20 5302 1223	20 5302 1244	20 5302 1225	17600	9	8	8	7	7	7
		20 5302 1225	17600	9	8	8	8	8	8
		20 5302 1227	17600	9	9	9	8	8	8
		20 5302 1228	17600	9	9	9	8	8	8
		20 5302 1228	17600	8	8	8	8	8	8
		20 5302 1237	17600	9	8	8	8	8	8
		20 5302 1242	24500	9	8	8	8	8	8
		20 5302 1244	24500	9	8	8	8	8	8
39 5303 1181	39 5303 1273	39 5303 1259	4310	9	9	8	8	8	8
		39 5303 1273	4310	9	8	8	8	8	8
60 5201 3041	60 5201 3158	60 5201 3041	7210	8	8	8	8	8	6
		60 5201 3048	7210	9	9	9	9	8	8
		60 5201 3054	7210	9	9	9	9	8	8
		60 5201 3055	7250	9	8	8	8	8	8
		60 5201 3095	7250	9	9	8	8	8	7
		60 5201 3098	7250	9	8	7	7	7	7
		60 5201 3101	7250	9	8	8	8	7	7
		60 5201 3102	7250	9	8	8	8	7	7
		60 5201 3109	6050	9	9	7	7	7	7
		60 5201 3142	6050	9	8	7	7	7	7
		60 5201 3158	6050	9	8	7	7	7	7
62 5201 1125	62 5201 1151	62 5201 1127	1990	6	6	9	9	8	6
		62 5201 1130	1990	5	6	9	9	8	6
		62 5201 1130	1880	6	6	9	9	8	7
		62 5201 1135	1880	6	6	9	9	8	7
		62 5201 1140	1880	6	6	9	9	8	7
		62 5201 1151	3940	7	6	6	6	8	8
17 5102 1100	17 5102 1199	17 5102 1100	8760	7	7	6	6	6	5
		17 5102 1102	7380	8	8	7	7	6	6
		17 5102 1119	7380	8	8	7	7	6	6
		17 5102 1121	7380	9	8	8	8	8	8
		17 5102 1127	7380	8	7	7	7	6	6
		17 5102 1137	7390	8	7	7	7	6	5
		17 5102 1164	7390	7	7	7	7	6	5
		17 5102 1166	7390	8	7	7	7	6	5
		17 5102 1166	7510	8	7	7	7	6	5
		17 5102 1180	7510	8	8	7	7	7	6
		17 5102 1199	7510	7	7	7	7	7	6
219 5101 3045	219 5101 3088	219 5101 3087	5750	U	9	8	8	8	8
		219 5101 3088	5750	7	7	6	6	6	5
219 5101 1000	219 5101 1060	219 5101 1001	7640	7	7	7	7	7	7
		219 5101 1005	7640	7	7	7	7	7	7
		219 5101 1009	7640	6	9	9	8	8	7
		219 5101 1024	7640	6	9	8	8	8	7
		219 5101 1046	7640	6	9	9	8	7	7
		219 5101 1054	7640	6	9	8	8	7	7
		219 5101 1060	7640	8	8	7	7	7	7
17 5102 3143	17 5102 3152	17 5102 3143	12300	9	8	8	8	8	7
		17 5102 3145	12300	9	8	8	8	8	8
		17 5102 3152	12300	9	8	8	8	8	7

APPENDIX D

Pavement Histories

Route 60, Towns of Gerry, Charolette, & Stockton
RM 60-5201-3041 to RM 60-5201-3158

The information contained in this pavement history has been taken from the Pavement Evaluation/Recommendation written by Region 5 Materials dated May 30, 1991. The pavement section included in this report was reconstructed in 1993 under D254798 consists of two areas with differing pavement histories. Area 1, from approximately RM 3170 to RM 3095 consists of 7-10 inches of HMA over PCC pavement. The PCC pavement was cracked and seated in 1984 under contract D250877 at which time the existing depth of HMA was constructed.

Area 2 from approximately RM 3095 to RM 3040 consists of two typical sections. The sections were used alternately in a 1973 project to improve site distance. The first section is full depth HMA over granular subbase. The second section consists of a PCC pavement which was widened and overlaid with 3± inches of macadam in the 1930's and then overlay with 3± inches of HMA in 1973. A major portion of this areas was overlaid with an additional 1 ½ inches of HMA in 1981.

The current pavement surface was constructed in 1993 under contract D254798. This contract consisted of two typical sections. The first typical section, constructed mainly in Area 1 as described above, consisted of removing the then existing HMA surface to a depth of 1 ½ inches and replacing with type 7F HMA. The second typical section, constructed mainly in Area 2 as described above, consisted of removing the then existing HMA surface to a depth of 5 inches and replacing with 2 inches of Type 3 and 1 ½ inches of Type 7F HMA.

Route 62, Frewsburg to Kennedy
RM 62-5201-1131 to RM 62-5201-1051

This pavement structure was constructed in segments from 1956 to 1967. Most of the road consisted of 5 inches or less of HMA and Macadam with in situ subbase material. During the 1980s several overlays were placed in and around the Village of Frewsburg. Work on Route 62 between the villages of Frewsburg and Kennedy consisted mainly of bridge replacement contracts and construction Exit 14 of the Southern Tier Expressway (I-86). No work was performed since 1956 to improve the pavement structure on any section of this pavement except at exit 14. This pavement section was reconstructed in 1996 under contract D256867. The pavement in the Village of Frewsburg and at the intersection of Route 62 and CR 318 was fully reconstructed. The remaining pavement was overlaid with two courses of HMA.

This pavement has two areas with markedly differing performances. The condition of this pavement changes abruptly at the intersection of Route 62 and CR 318. Both areas of pavement were constructed to the same typical cross sections. The same mixture was used for

top course on all areas of this project. Two pavers were used to place top course. Although construction records are not clear for all paving days at least one of the machines was used to pave in both well and poor performing areas. This investigation could not find one difference in design or construction practices, according to construction records, between the well and poor performing areas.

I-86, x17 to x20, Towns of Cold Spring and Red House
RM 17-5112-1100 to RM 17-5112-1199

This pavement was constructed in the mid to late 1960s. The original pavement consisted of 9 inch thick jointed reinforced portland cement concrete pavement (JRPCP) with 60 foot slab lengths. No major rehabilitation was performed on this pavement until D254572 in 1993. This project consisted of cracking and seating the JRPCP and placing a 5 inch overlay of hot mix asphalt.

APPENDIX E

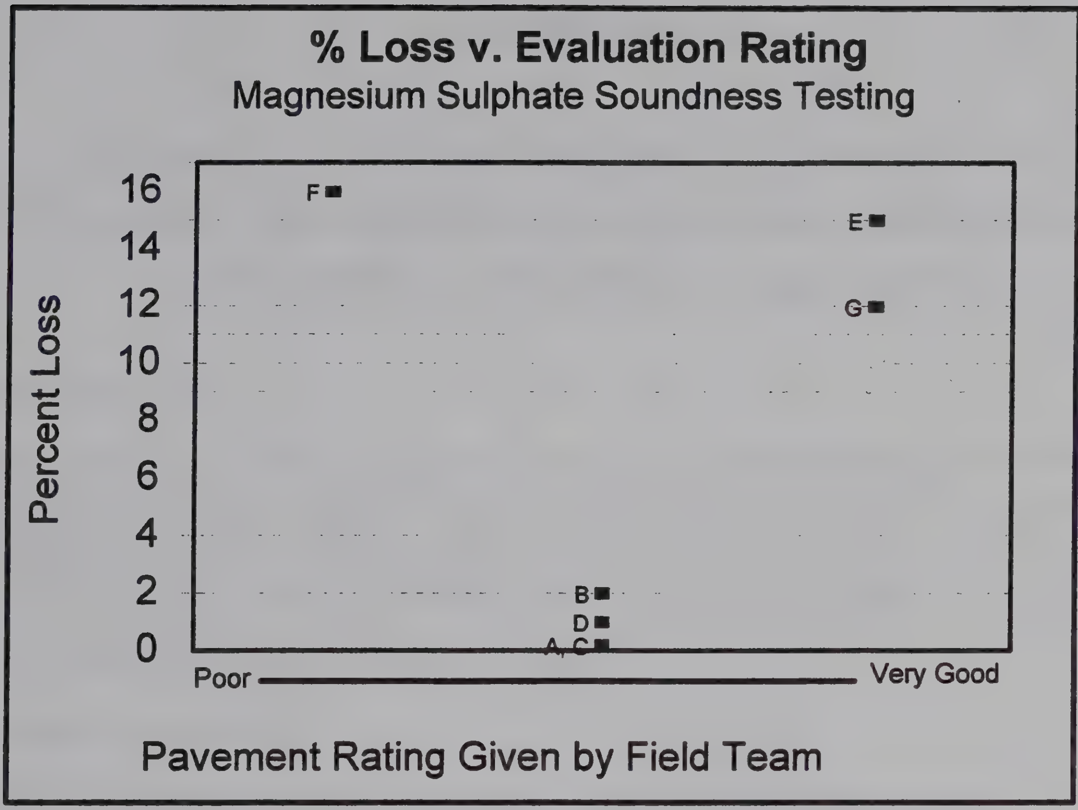
Data From Petrographic Analysis of Pavement Cores

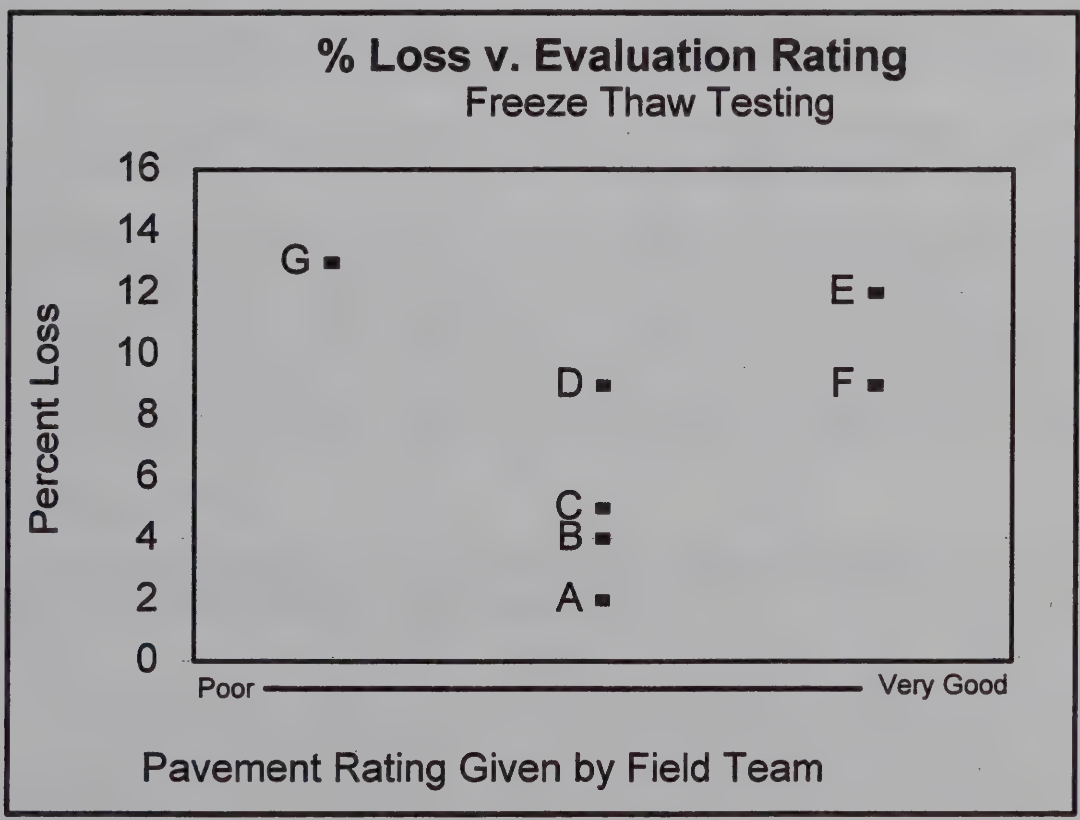
The following data were gathered from the Gravel Study sites from petrographic analysis of pavement cores, which were used to verified the identity of the coarse aggregate sources given in the project files. In addition, magnesium sulfate soundness and freeze-thaw test data were derived from biennial test results. The pavement sample from I-86 was untestable. An average of the petrographic contents of the samples from Routes 60 and 62 was used to complete the table below.

PETROGRAPHIC CONTENT OF PAVEMENT SAMPLES					
Source of Record	G	G	F	E	E
Rock Type	Average Percent Composition				
Graywacke SS	55	64	69	57	56
White SS	3	3	2	2	2
Red SS	5	6	4	6	8
Chert	3	3	4	4	4
Igneous/Metamorphic	6	7	3	6	7
Limestone	25	17	17	17	12
Dolomite	4	Tr	3	10	11

COMPARISON OF HISTORICAL DURABILITY TESTING					
Source	Average Mag. Sulfate Soundness (%)	Average Freeze-Thaw Loss (%)	Average Sandstone Content	Average Carbonate Content	Type of Source
A	<1	2	0	71[1]	Crushed Stone, Onondaga Formation
B	2	4	0	39[1]	
C	<1	5	0	35[1]	
D	1	9	0	89[1,2]	
E	12	12	63	27	Crushed Gravel, Outwash Terrace
			66	23	
F	15	9	75	20	Crushed Gravel, Outwash Delta
G	16	13	63	29	Crushed Gravel, End Moraine
			75	17	
			67[3]	23[3]	

(1) Values of % carbonate were derived from sample records from the early to mid 1990s
(2) Source D is always used in a blend for top course paving.
(3) Values were calculated by averaging the results of the Rt. 60 and Rt. 62 cores


% Loss v. Evaluation Rating
Magnesium Sulphate Soundness Testing
Percent Loss
16
14
12
10
8
6
4
2
0
F
E
G
B
D
A, C
Poor
Very Good
Pavement Rating Given by Field Team


% Loss v. Evaluation Rating
Freeze Thaw Testing
Percent Loss
16
14
12
10
8
6
4
2
0
G
E
D
F
C
B
A
Poor
Very Good
Pavement Rating Given by Field Team

APPENDIX F

Evaluation of the Friction Characteristics of Flexible Pavements Constructed with Blends of Dolomite and Gravel Aggregates

OBJECTIVE

The purpose evaluation was to address the issue of pavement friction of flexible pavements constructed with blends of low-residue dolomite and gravel. During the field investigation of the Gravel Study, it was observed, among all those gravel pavements in the study, there were significant numbers of coarse aggregate particles that had "pocked", leaving a socket where the particle had been. There was, therefore, concern that the loss of gravel particles in blends with dolomite, where the gravel was supposed to provide needed friction, would result in friction performance below the design target (FN_{40}= 32).

PAVEMENT SELECTION

Each of the projects for the evaluation had to meet the following study criteria:

1. They all contain sections that carry high traffic volumes (Lane AADT> 4,000) and many include intersections, conditions for which there is the greatest safety concern.

2. They are all over two years old and so have reached an equilibrium (terminal) friction condition which will be maintained throughout their remaining service lives.

Six projects were identified as being over two years old and containing a blend of low-residue dolomite and gravel, by Region 5, Materials. All were found to be in overall excellent condition (a summary of pavement sufficiency ratings is provided below) and all exhibited the pocking that was of concern. Pavement cores were taken from each project so that the blend percentage of carbonate and non-carbonate coarse aggregate particles could be determined (see the table below). It was found that in each project, the percent non-carbonate met the requirement. Finally, each project was tested with the drag force friction trailer to determine the friction number (FN_{40}).

INVESTIGATIVE TEAM

The team for this project consisted of Bill Skerritt, Materials Bureau, Engineering Geology, and Brad Allen, Materials Bureau, Field Engineering 2.

Findings

All the gravel blend pavements evaluated contained sandstone between approximately 25% and 50% with overall noncarbonate contents of 28% or greater. Pocking or coarse aggregate particle loss in each pavement was estimated to be less than 5% of the total coarse aggregate. All the gravel blend pavements evaluated are currently providing friction that exceeds the design target (FN_{40} = 32). From these, the following conclusions can be drawn:

1. Gravel blends similar to those evaluated in this study may be expected to maintain pavement friction that exceeds the design target throughout their service lives.

2. Adequate friction will be maintained in such pavements in spite of some loss of gravel particles from the surface.

SUMMARY OF GRAVEL BLEND FRICTION DATA

#	Route	RM	Lane AADT	Petrographic Results[1]		% Non-Carbonate	Avg FN_{40} / Low FN_{40}
1	263 & 78	263/5301/1080-1102 & 78/5302/1331 - 78/5403/1024	4.5K	Sandstone Carbonate Chert Granitics Shale	34 58 1 4 3	39	56.0/40.4
2	31	31/5401/2000-2088	4.0K	Sandstone Carbonate Chert Granitics Shale	27 66 3 3 0	33	52.4/45.0
3	31	31/5401/2147-3002	5.0K	Sandstone Carbonate Chert Granitics Shale	53 40 2 3 1	58	57.2/45.6
4	104	104/5401/2000-2033	2.1K-4.8K	Sandstone Carbonate Chert Granitics Shale	24 72 1 3 0	28	51.0/43.4 (2.1K) 44.2/37.4 (3.3K) 43.0/37.6 (4.8K)
5	I-190	190I/5401/1012-1039	7.5K-14K	Sandstone Carbonate Chert Granitics Shale	36 60 2 2 0	40	50.5/45.7 (7.5K) 47.3/44.5 (14K)
6	62	62/5404/1003-3001	6.0K	Sandstone Carbonate Chert Granitics Shale	34 62 1 2 0	37	47.8/35.3

(1) Carbonate particles are mostly low-residue Lockport Dolomite with some mixed limestone and dolomite derived from the gravel.

PAVEMENT SURFACE RATINGS FOR BLEND SITES

Start	End	Reference Marker	AADT	1995	1996	1997	1998	1999	2000
263 5301 1080	263 5301 1102	263 5301 1081	19500	7	7	7	7	7	7
		263 5301 1102	19500	6	6	U	9	8	8
78 5302 1331	78 5403 1024	78 5302 1332	29500	7	7	7	7	7	7
		78 5302 1334	29500	7	7	U	9	8	8
		78 5403 1001	21900	5	U	U	9	8	8
31 5401 2000	31 5401 2088	31 5401 2002	12800	8	U	9	9	9	8
		31 5401 2007	12800	6	U	9	9	9	9
		31 5401 2010	12800	7	U	9	9	9	9
		31 5401 2011	12800	7	U	9	8	8	8
		31 5401 2012	9840	7	U	9	8	8	8
		31 5401 2016	9840	6	U	9	9	9	9
		31 5401 2018	8200	6	U	9	9	9	9
		31 5401 2038	8200	6	6	9	9	9	9
		31 5401 2056	8200	6	K	9	9	9	9
		31 5401 2062	11800	5	K	9	9	8	8
		31 5401 2066	11800	5	K	9	9	8	8
		31 5401 2077	11800	5	K	9	9	8	8
		31 5401 2079	11800	5	U	9	9	9	8
		31 5401 2081	12700	6	U	9	9	8	8
		31 5401 2087	7130	5	U	9	9	8	8
31 5401 2147	31 5401 3002	31 5401 2147	7470	8	7	7	7	6	6
		31 5401 2148	7470	5	U	U	9	8	7
		31 5401 2165	8130	5	5	U	9	9	8
		31 5401 2167	12200	6	6	U	9	9	8
		31 5401 3000	8820	6	6	U	9	9	8
		31 5401 3001	8820	6	6	U	9	9	8
		31 5401 3002	8820	7	7	U	9	8	8
104 5401 2000	104 5401 2033	104 5401 2003	2950	5	4	K	8	8	8
		104 5401 2006	7130	4	4	K	8	8	8
		104 5401 2010	7130	8	8	8	8	8	8
		104 5401 2013	7130	5	5	9	9	8	7
		104 5401 2015	7130	6	5	9	9	8	7
		104 5401 2020	12000	6	U	9	8	8	7
		104 5401 2022	19000	6	U	9	8	8	7
		104 5401 2024	19000	6	U	9	8	8	7
		104 5401 2026	19000	6	U	9	8	8	7
		104 5401 2028	13200	6	U	9	8	8	7
		104 5401 2030	13200	6	K	9	8	8	7
		104 5401 2032	13200	6	K	9	8	8	7
		104 5401 2032	7070	6	K	9	8	8	7
		104 5401 2033	7070	6	K	9	8	8	7
190I 5401 1012	190I 5401 1039	190I 5401 1012	31200	6	6	U	9	8	8
		190I 5401 1026	31200	6	6	U	9	9	8
		190I 5401 1032	27000	6	6	U	9	8	8
62 5404 1003	62 5404 3001	62 5404 1003	26700	NA	NA	7	7	6	5
		62 5404 1004	26700	6	6	U	U	9	8
		62 5404 2003	23600	5	5	U	U	9	9
		62 5404 2012	20700	5	5	U	U	9	9
		(62 5404 3002)	19400	7	7	U	U	9	9

NA = No Data Available U = Under Construction (Not rated) K = Rating of 10 (Best Rating)